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ENERGY EFFICIENT FISH HATCHERY

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Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Énergie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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1.0 EXECUTIVE SUMMARY

The Wolverton Fish Hatchery project involved the application of heat pump technology and solar energy to a small fish hatchery with the objective of reducing both the amount of energy required for fish production and the time required to produce young smolts.

Other techniques demonstrated by this project were heating the water during the egg stage thereby minimizing the amount of food required, re-using 70% of the heated water and water aeration.

In the opinion of the proponent this project has been very successful. Originally, salmon smolts were to be raised but due to disease they perished; therefore no performance monitoring could be accomplished. Recent trials with trout smolts show very promising savings. Based on these results a theoretical saving of \$76,000 per year can be achieved and the growth period reduced by 50%.

1.0 SOMMAIRE RECOMMANDATION

Le projet de la piscifactory Wolverton consistait à appliquer la technologie de la pompe à chaleur et de l'énergie solaire à une petite piscifactory dans le but de réduire tant la quantité d'énergie requise pour la production des poissons que le temps nécessaire pour obtenir de jeunes truites de deux ans.

Parmi les autres techniques qui ont été démontrées dans ce projet, il y a le chauffage de l'eau pendant la période de développement des oeufs qui a permis de minimiser la quantité de fourrage nécessaire, par la réutilisation de 70% de l'eau chaude et l'aération de l'eau.

Selon le responsable du projet, les résultats ont été très positifs tant du point de vue énergétique que de celui de la pisciculture. Les coûts énergétiques peuvent être réduits de jusqu'à 76 000 \$ par année et la période de production de 50%.

2.0 INTRODUCTION

Commercial trout rearing is rapidly becoming a sizable industry in North America and should be thought of as a conservationist industry. The trout producer is mainly in business to satisfy a consumer demand for foodstock, but by filling this need he relieves the fishing pressure on wild stock. He also uses waste protein from the fishing industry to grow a palatable product.

Canada now imports most of its commercial trout because of a short growing season. Recent advances in water recycling equipment that largely overcome climatic disadvantages offers the opportunity for Canadian trout producers to compete. Small producers can best adopt this equipment by employing a low-grade technology policy that minimizes capital costs and operational complexities. By demonstrating the commercial viability of this approach, Wolverton's Fish Hatchery will guide future producers toward an energy efficient philosophy that saves fuel and increases productivity.

The project is extremely cost effective when compared to a conventional hatchery, since all of the capital costs are recaptured in the first two years of production.

The purpose of this project was to hatch and rear salmonid smolts, young salmonids large enough for seawater entry, in a water-reuse hatchery system. These smolts were needed to help solve a major problem for New Brunswick aquaculturists -- the scarcity of healthy young fry for stocking.

The objective at Wolverton's Fish Hatchery Ltd. was to overcome the freshwater limitation by reusing 90% of the culture water; and by heating this water with a heating system to an ideal temperature for fish growth (15° C), produce a smolt in 1/2 the usual time.

This new arrangement allows Wolverton's fish hatchery to reduce its total annual energy consumption by 9 billion BTU's.

3.0 DESCRIPTION OF THE DEMONSTRATION

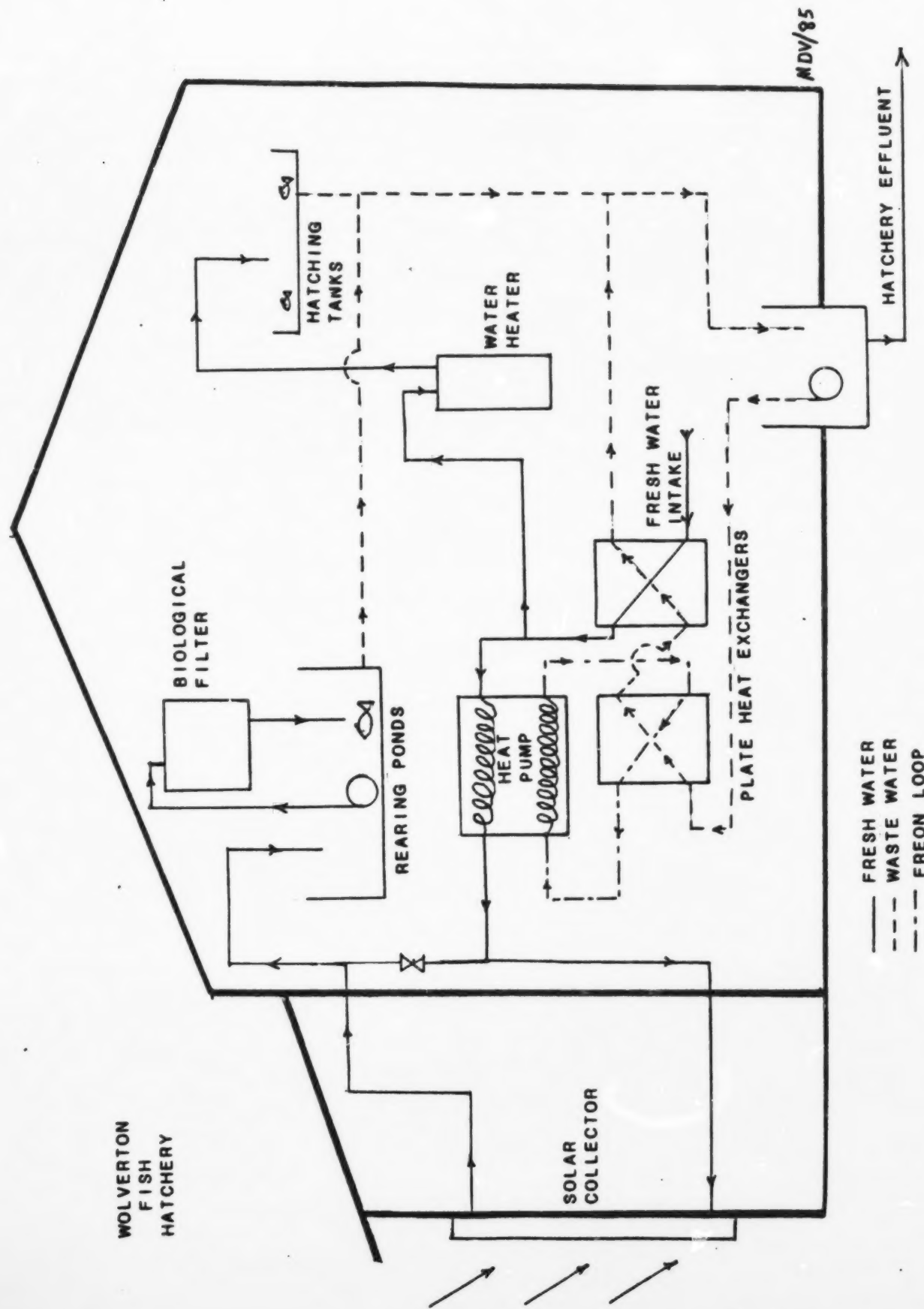
This demonstration consisted basically in installing approximately 15 square meters of solar collectors, building the re-use system, and installing the heat pump. Here are some specific details on the installation. The entire system can be visualized in figure 1.

The hatchery building measures 24.4m X 17.7m (80' x 58') and consists of a hatching room (5.8m x 7.3m; 19'x 24'); starting room (4.9m x 24.4m; 16'x 80') and a rearing room (12.2m x 18.6m; 40'x 61'). All systems are monitored by a micro-computer. The entire hatchery is heavily insulated and the insulation is covered by a vapor barrier.

The starting room, facing 5° east of South, is faced with thermopane glass and solar collectors. As a result, the water in the hatching room, the rearing room and the starting room is heated. Since water from the fish tank is constantly circulating through each biological filter, a total of 113,000 liters of water are heated by this system.

The water to the building is a spring providing 273 liters per minute and a 91 meter deep, 4 cm. diameter well that supplies 228 liters per minute.

WOLVERTON FISH HATCHERY



The re-use system consists of 2' X 16' hatching troughs made of 3/4" plywood and 2" x 10" planks coated with fiberglass. Seventy percent (70%) of the water is being re-used, without biological filtration, and without ammonia problems. Twenty (20) fiberglass tanks are also in use. The re-use system consists of one 5000 liter settling tank, one 4000 liter biological tank, media with planted bacteria, six 4.25 meter tanks consisting of 6 galvanized steel panels lined with non-toxic paint (11.2 cm. deep). A 1/3 HP submersible pump is used to circulate the water.

Water is heated during the egg stage since less water is needed at that time. However, since the water is recirculated, ammonia, nitrates and nitrites build up in the water. These are removed by the biological filter and filtering media. Another problem that arises as a result of re-using the water is oxygen depletion. This is overcome by aerating the water.

Since heating the water is very expensive, it is heated by some of the most economical methods available, that is, a heat pump, solar collectors and by using thin walled fiberglass tanks which were painted black in order to better absorb solar energy.

Referring to Figure 1, fresh water enters the system and flows through the first plate heat exchanger. The fresh water recovers heat from the warmer recirculating waste water. The fresh water then proceeds to the heat pump where it is further heated. The heat pump uses the second plate heat exchanger to recover heat from the waste water via a freon loop through the heat exchanger. The freon returns to the heat pump where it is compressed and heats the incoming fresh water. The freon then passes through an expansion valve and returns to the plate heat exchanger to begin the process over again.

If the water exiting the heat pump is sufficiently warm (15° C) it bypasses the solar collectors and is fed directly into the rearing ponds. Otherwise the water is circulated through the solar collectors to be additionally warmed. This bypass system is regulated by an automatic control valve which senses the water temperature leaving the heat pump and opens or closes the valve accordingly.

All waste water from the rearing and hatching ponds is drained to the waste water pit. Here the warm waste water is recirculated through the plate heat exchanger. Any excess waste water is drained away by the hatchery effluent.

The heat pump installed in this project is a ground water source heat pump. Because the copper piping normally used in water source heat pumps would impart toxicity to the water and eventually to the fish, a stainless steel heat exchanger was chosen as part of the heat pump. The pump heats 18 gallons of water per minute with a (9° C) 15° F rise.

4.0 MONITORING

The system is monitored by a Commodore computer which monitors water flows and temperatures; an alarm system which detects water flow and power supply to heat pump; and an alarm system in the starting room which detects water flow and power supply. These systems are connected to a telephone system which automatically notifies three different parties that there is a problem. It will also notify the fire department if there is a fire at the hatchery. The sensors are located at the intake and outlet of the heat pump and solar collectors; hatchery room and rearing ponds. Flow indicators installed in the heat pump indicate the amount of water heated.

This performance monitoring system was installed but before any readings could be taken the fish contracted a fatal disease common to salmon, called *Aeromonas Salmonicida* (furunculosis), and had to be disposed of. Due to time limitations and costs no new fish stocks were commenced to replace the deceased stock; therefore, no performance monitoring of the system was possible. Appendix I is an estimate of the potential savings for the designed system. A graph illustrating theoretical outputs for the solar collector is also shown in Appendix II.

5.0 COST/BENEFIT ANALYSIS

<u>ITEM</u>	<u>AMOUNT ALLOCATED</u>	<u>ACTUAL COST</u>
Air System	\$2,000.00	\$2,709.60
Biological Filters	5,000.00	5,394.00
Filter Media & Ass.	8,000.00	8,277.50
1/3 HP Subm. Pumps	4,000.00	4,184.00
Piping	5,000.00	5,229.53
Alarm System	3,500.00	-----
Structual Supports	2,000.00	4,158.08
Additional Well & Pumps	5,000.00	5,136.00
Insulation of Tank Room	3,500.00	3,862.00
Roof Preparation	1,000.00	1,058.50
Water Piping	1,000.00	1,060.73
Controls	1,000.00	1,053.00
Fiberglass Covers	4,500.00	4,614.00
Tank Insulation	1,500.00	1,594.00
Site Preparation	1,500.00	1,552.00
Shell Piping	2,500.00	2,644.00
Tube Ducts	5,000.00	4,948.00
Misc. Access.	1,000.00	1,097.76
		\$58,572.70

In addition to the items stated, the following items were purchased by Wolverton's Fish hatchery to complete the system. These items were not included by the engineering consultant firm, Carpenter Associates Ltd., in the original proposal:

<u>ITEM</u>	<u>COST</u>
Generator for back-up power & labour	\$9,500.00
Solar Collectors	1,000.00
Stand-by Pump	1,000.00
Heat Pump	6,800.00
Water Testing Equipment	2,000.00
Exhaust Rotary Air Compressor for back-up supply	500.00
	\$20,800.00

From the capital cost analysis, the total incremental cost of energy saving equipment is \$79,369 which includes labor, materials, engineering and construction administration. Tables I through IV (Appendix 1) detail theoretical annual savings of \$76,452 in fuel costs. If one compares the energy-efficient hatchery to a simple flow-through hatchery with the same production capacity, it suggests a pay-back period of about one year.

Of the total incremental cost of this project, the N.B. Energy Secretariat and Energy, Mines and Resources Canada contributed \$61,754 through the Conservation and Renewable Energy Demonstration Program

6.0 CONCLUSIONS AND RECOMMENDATIONS

This system seems to be the answer to our short growing season. It enables New Brunswick to compete with Southern Ontario and Southern New England States by changing our environment to equal theirs. This also enables New Brunswick fish growers to produce a one year smolt whereas it normally would take two years to produce the same fish.

The seawater environment of the New Brunswick coast, like the Pacific Northwest, is ideal for salmonids because of the relatively clean water and cool temperatures. However, trout and salmon must spend their early life in freshwater. Unlike the Pacific Northwest, freshwater resources near the New Brunswick coast are limited. Surface water is too cold in winter, too warm in summer, and contains a number of fish pathogens. Groundwater, in amounts greater than 5-10 gallons/minute (gpm) needed for domestic wells, is relatively scarce, and in rapidly increasing demand for human use. Groundwater temperature averages 6° C. At this temperature conventional flow-through hatchery requires 19-22 months to grow rainbow trout to a minimum seawater size of 6 inches, and a minimum flow of 50 gpm for each 20,000 smolts produced.

We highly recommend all of the energy conservation features described above to any Canadian trout producers.

APPENDIX I
Theoretical Savings

TABLE I

COST OF FUEL FOR WARM WATER (NO REUSE)
(Neglecting Heat Loss of Conductivity)
TO REAR 125,000 FINGERLINGS

MONTH	WATER G.P.M.	WATER lbs/hr	REQ'D TEMP. °F	TEMP* DIFF. °F	REQ'D ENERGY MBTU	FUEL** COST \$/MO
October	15	8,000	54	12	100	966
November	30	15,000	56	14	210	2,070
December	100	50,000	56	14	700	6,900
January	160	80,000	54	12	960	9,522
February	300	150,000	54	12	1,800	17,940
March	450	225,000	52	10	2,250	22,356
April	600	300,000	50	8	2,400	23,736
May (1/2)	800	400,000	50	8	3,200	16,008
ANNUAL TOTAL					11,620	\$99,498

*Assume 42° F Groundwater Temperature

**Fuel at \$1.38/gal.

TABLE II

**COST OF FUEL FOR WARM WATER REUSE SYSTEM
(Neglecting Heat Loss of Conductivity)
TO REAR 125,000 FINGERLINGS**

<u>MONTH</u>	<u>MAKE-UP WATER G.P.M.</u>	<u>MAKE-UP WATER lbs/hr</u>	<u>REQ'D TEMP. OF</u>	<u>TEMP* DIFF.</u>	<u>REQ'D ENERGY MBTU</u>	<u>FUEL** COST \$/MO</u>
October	15	8,000	54	12	100	966
November	30	15,000	56	14	210	2,070
December	50	25,000	56	14	350	3,450
January	80	40,000	54	12	480	4,692
February	150	75,000	54	12	900	8,970
March	150	75,000	52	10	750	7,452
April	150	75,000	50	8	600	5,934
May (1/2)	200	100,000	50	8	800	4,002
ANNUAL TOTAL						\$37,536

*Assume 42° F Groundwater Temperature

**Fuel at \$1.38/gal.

TABLE III

COST OF FUEL FOR WARM WATER WITH
REUSE SYSTEM PLUS SOLAR COLLECTORS

<u>MONTH</u>	<u>REQ'D ENERGY (MBH)</u>	<u>SOLAR* ENERGY (MBTU)</u>	<u>FUEL ENERGY (MBH)</u>	<u>FUEL COST \$/MO</u>
October	100	40	60	552
November	210	20	190	1,932
December	350	10	340	3,312
January	480	10	470	4,692
February	900	20	880	8,694
March	750	40	710	7,038
April	600	40	560	5,520
May (1/2)	800	40	760	3,726
ANNUAL TOTAL			3,970	\$35,466

* Based on 1500 s.f. lo-technology collector, 20% efficiency in December, January; 50% efficiency in November, February and 80% efficiency in October, March, April, May. Maximum capacity (100% eff) 750 BTU/s.f./day.

TABLE IV

FUEL SAVING FOR WARMING WATER
WITH PREHEAT EXCHANGER ON HATCHERY
EFFLUENT (For Reuse System)

MONTH	LBS/HR DISCHARGE WATER	TEMP DIFF. F	RECAPTURED ENERGY MBTU	FUEL SAVINGS \$
October	8,000	12	40	414
November	15,000	14	90	828
December	25,000	14	150	1,518
January	40,000	12	200	1,932
February	75,000	12	300	3,036
March	75,000	10	225	2,208
April	75,000	8	150	1,518
May (1/2)	100,000	8	200	966
TOTAL ANNUAL SAVINGS -			1,355	\$12,420

TABLE V

Total Project Savings = \$98,498 - \$35,466 + \$12,420 = \$76,452

APPENDIX II

SOLAR COLLECTOR OUTPUT

